Saskatchewan Agriculture

Economics Branch

Farm Management

FERTILIZER ECONOMICS

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Foreword

Since the early 1970's fertilizer use has increased dramatically in Saskatchewan. This was particularly so for nitrogen based fertilizer, although phosphate fertilizer useage increased greatly as well. During this period farmers gradually increased cropped acreage and reduced fallow acreage. This resulted in large increases in stubble cropping which requires large inputs of nitrogen fertilizer. Declining soil quality has also been a factor in increased nitrogen fertilizer recommendations. Extra nitrogen is often required on summerfallow fields, as well.

In 1985, fertilizer consumption leveled off. Useage was only slightly higher than in 1984. Declining grain prices and tighter profit margins have caused this decline.

The economics of fertilizer use involves many considerations. Fertilizer decisions on farms involve not only the basic decision to apply fertilizer to land but also the most economical level of application. This is in contrast to the use of most chemicals on farms where it is either a matter of using a chemical at the rate that will give weed control or not using the chemical at all.

The economics of fertilizer use is affected by crops grown. Some crops tend to give a greater yield response to fertilizers than other crops.

This publication examines the common fertilizer decisions farmers must make. It indicates methods of determining the most profitable level of fertilizer use.

Farm Management Section
Economics Branch
Saskatchewan Agriculture
March, 1986.

Selecting Fertilizer Rates

The principle of diminishing return applies to fertilizer use. It is an effective way of selecting a profitable amount of fertilizer to use. The principle means **"that as you add a production input (eg. fertilizer) to a fixed resource (eg. one acre of land) while holding all other inputs constant, output (yield) will first increase at an increasing rate, then at a decreasing rate and finally total output will decline"**. When the price of both the input (fertilizer) and output (grain) are known, this principle can be used to determine the most profitable amount of input (eg. fertilizer) to use.

Table 1 shows an actual soil test report recommendation from the Saskatchewan Soil Testing Laboratory. The additional yields are from the soil test report; the overall yields are estimated, assuming a base yield of 30 bu/ac without N fertilizer applied.

The first 10 pounds of fertilizer adds 2.5 bushels per acre to yield, the second 10 pounds adds 2.2 bushels per acre and so on until at 70 pounds per acre no further yield increase occurs. This schedule illustrates the principle of diminishing returns. The amount of fertilizer nitrogen that will result in the most profit can now be determined based on the fertilizer and grain prices.

Table 1: Example Analysis

Fertilizer Nitrogen Applied (lb/acre)	Wheat Yield (bu/acre)	Additional Yield (bu/acre)
0	30	
10	32.5	2.5
20	34.7	2.2
30	36.5	1.8
40	38.0	1.5
50	39.2	1.2
60	40.0	.8
70	40.5	.5
80	40.5	0
90	40.5	0
100	40.5	0

Assume that the price of fertilizer nitrogen is 30¢ per pound and the price of grain is $5.00 per bushel. Then the cost of each increment of fertilizer and the corresponding value of the yield can be determined. This is presented in table 2.

Each 10 pounds of fertilizer costs $3.00 per acre. The first increment adds 2.5 bushels of yield per acre at a value of $12.50 when the price of wheat is $5.00 per bushel. Therefore, there is a profit of $9.50/acre ($12.50 - $3.00). Each successive unit of fertilizer produces a smaller added value until at 70 pounds of fertilizer the return is only $2.50 per acre as compared to a cost of $3.00 per acre. Obviously, it would not pay to added the seventh 10 pound unit of fertilizer. The most profitable amount of fertilizer to apply is 60 lbs.

At 60 pounds of fertilizer it would result in an additional wheat yield of 40.0 bu/ac - 30.0 bu/ac or 10.0 bushels per acre at a value of 10.0 bu/ac x $5.00/bu or $50.00. The cost of fertilizer would be 60 lb/ac x $0.30/lb or $18.00. The net return is $32.00 per acre. Lower rates of fertilizer useage would result in lower net profit. With 50 pounds of nitrogen, there would be an added yield of 39.2 bu/ac - 30 bu/ac or 9.2 bu/ac. The net return would be (9.2 bu/ac x $5.00) - (50 lb/ac x $0.30/lb) = $31.00.

This is $1.00 less profit than the optimum rate of fertilizer useage.

If the price of grain dropped to $2.50 per bushel, Table 2 indicates that it would still pay to apply fertilizer but not to the same extent as if the price was $5.00/bushel. In this case it would pay to add 50 pounds of fertilizer since this is the point where the added income of $3.00/acre equals the added cost of $3.00/acre.

Table 2 Fertilizer Costs and Returns

Fertilizer Nitrogen Applied (lb/ac)	Fertilizer Nitrogen Increments (lb/ac)	Cost of Fertilizer Increments (30¢/lb)	Added Yield (bu/ac)	Value of Added Yield ($5/bu)	Value of Added Yield ($2.50/bu)
0					
10	10	$3.00	2.5	$12.50	6.25
20	10	3.00	2.2	11.00	5.50
30	10	3.00	1.8	9.00	4.50
40	10	3.00	1.5	7.50	3.75
50	10	3.00	1.2	6.00	3.00
60	10	3.00	.8	4.00	2.00
70	10	3.00	.5	2.50	1.25
80	10	3.00	0	0	0
90	10	3.00	0	0	0
100	10	3.00	0	0	0

As with changing grain prices, fertilizer prices affect the most profitable level of fertilizer use. During periods of decreasing grain prices and/or increasing fertilizer prices, the amount of fertilizer used should be reduced to maximize profit. During periods of increasing grain prices and/or declining fertilizer prices, the amount of fertilizer used should increase.

This example indicates that if grain prices decrease, it would not be prudent to eliminate fertilizer use, but reduce the amount of fertilizer used per acre to the point where the added costs equal the added returns.

Determining the Cost of Fertilizer

Fertilizer cost should include the cost of the actual fertilizer product plus other costs such as freight, handling, storage and application. Further, it is necessary to determine the actual cost of the nutrients contained in the fertilizer product to determine the most profitable level of fertilizer use.

(a) Cost of Nutrients
The following procedure indicates the method of determining the cost of nutrients when the value of the commercial product is known.

i) 46-0-0 priced at $227 per ton ($250/tonne). This fertilizer contains 46% nitrogen (N). Therefore, there are 46/100 x 2000 lb = 920 lb of N in one ton of 46-0-0 fertilizer. There are no other nutrients in the product, therefore, the cost of N is $227/920 lb = 24.7¢/lb

ii) 12-51-0 priced at $318 per ton ($350/tonne).
Quantity of Nitrogen (N)
= 12/100 x 2000 lb = 240 lb
Quantity of Phosphate(P2O5)
= 51/100 x 2000 lb = 1020 lb

Determine the value of N in the product based on a nitrogen based fertilizer (see previous example) and subtract this amount from the total value of the product. The difference is the value of the phosphate.

Value of 12-51-0	$318.00
Value of N (240 lb x $.247/lb)	59.28
Value of P_2O_5	$258.72

Therefore, the cost of P2O5 = 258.72/1020 lb = 25.3¢/lb

(b) Application Costs
Nitrogen fertilizers are most commonly applied prior to seeding either by broadcasting or deep banding. The following cost guidelines for nitrogen application is based on machinery cost guidelines published by Saskatchewan Agriculture.

Broadcasting (fertilizer spreader)	$1.80/ac
Deep Banding (air seeder)	6.40/ac
Deep Banding (anhydrous ammonia)	2.60/ac1/

1/ includes only tractor costs. The value of an anhydrous ammonia applicator is normally included in the price of the fertilizer.

c) Trucking - farm storage to field
If fertilizer is stored on the farm, then it must be moved from the storage facility to the field for application. The following are the estimated times required to move 9 tons of fertilizer in a three ton truck from farm storage to a field five miles away.

	(9 ton load) Nitrogen Fertilizer	(9 ton load) Phosphate Fertilizer
Loading at Bin	1/2	1/2
Hauling to Field (5 miles)	1/4	1/4
Unloading in field		
- auger	3/4	
- drill fill (into seeder)		1 3/4
	1 1/2 hr	2 1/2 hr

The cost guidelines for a three ton truck indicate a rate of $50.00 per hour. This would result in a cost per ton of nitrogen fertilizer of $\frac{(1\ 1/2 \times \$50)}{9\ t}$ or $8.33 per ton.

and $\frac{(2\ 1/2 \times 50)}{9\ t}$ or $13.89 per ton for phosphate fertilizer.

d) Freight to Farm
Trucking costs to the farm, if applicable, should be considered. However, fertilizer prices may be quoted as a laid in price at the farm.

e) Storage Costs
Fertilizer may be picked up at a fertilizer dealer when required or picked up in advance and stored on the farm. If stored on the farm, storage costs must be considered. If picked up at a fertilizer dealer when required, the actual fertilizer will likely cost more.

The following example indicates a procedure to calculate fertilizer bin storage costs.

Assumptions:

Bin size - 55 tons
Type - metal hopper on concrete
Original Cost - $4000
Life - 40 years
Repairs - 1/2%/year

	costs/year
Repair Allowance $4000 x .005 =	$20
Insurance $4000 x 1% =	$40
Depreciation $\frac{4000 - 400}{40 \text{ years}}$ =	$90
Interest on Investment $\frac{4000 + 400}{2}$ x 12% =	264
Total Annual Cost	$414

Cost/ton = $\frac{414}{55}$ = $7.53

f) Interest Costs

Interest on the value of the fertilizer is a cost if purchased prior to use. Using a 12% interest rate, the following table shows the monthly interest cost for various per ton costs of fertilizer.

Number of Months	Cost of Fertilizer per Ton (interest cost per ton of fertilizer)					
	$175	$200	$250	$300	$350	$400
1	$1.75	$2.00	$2.50	$3.00	$3.50	$4.00
2	3.50	4.00	5.00	6.00	7.00	8.00
3	5.25	6.00	7.50	9.00	10.50	12.00
4	7.00	8.00	10.00	12.00	14.00	16.00
5	8.75	10.00	12.50	15.00	17.50	20.00
6	10.50	12.00	15.00	18.00	21.00	24.00

g) Summary of Fertilizer Costs

By adding all the component costs, the total cost of purchasing, handling, storage, trucking and application can be determined.

Example

A. Deep Banding with an Air Seeder

Purchase 46-0-0 fertilizer in December for spring application

	$/ton
Cost of Product in December (Laid-in Price)	$227.00
Trucking to a Field	8.33
Storage	7.53
Interest (5 months)	11.35
Application cost: $6.40/acre apply 50 lb of N (109 lb of 46-0-0) 1 ton will cover $\frac{2000 \text{ lb}}{109 \text{ lb/ac}}$ = 18.3 acres	
Cost/ton = 18.3 ac x 6.40 ac =	117.12
Total cost per ton	$371.33

One ton contains 920 lb of N. Therefore the cost per pound of N applied is $\frac{371.33}{920}$ = 40.4 ¢

B. Broadcasting with a Fertilizer Spreader

Purchase 46-0-0 fertilizer in December for spring application.

	$/ton
Cost of Product in December (Laid in Price)	$227.00
Trucking to Field	8.33
Storage	7.53
Interest (5 months)	11.35
Application Fertilizer Spreader $1.80/acre Apply 50 lb of N (109 lb of 46-0-0) 1 ton will cover $\frac{2000 \text{ lb}}{109 \text{ lb/ac}}$ = 18.3 acres	
Cost/ton = 18.3 x 1.80/ac	32.94
Total Cost/ton	$287.15

Therefore, the cost per pound of N applied is $\frac{287.15}{920 \text{ lb}}$ = 31.2¢

C. Deep Banding with an Anhydrous Ammonia Applicator

Purchase 82-0-0 fertilizer in December for spring delivery and pickup. Anhydrous machine and delivery of product supplied by fertilizer dealer.

	$/ton
Cost of Product in December (Laid-In Price)	$422.00
Interest (5 months)	21.10
Application (Tractor and labor) - $2.60/acre	
Apply 50 lb of N (61 lb of 82-0-0)	
1 ton will cover $\frac{2000}{61\ lb}$ = 32.8 acres	
Cost/ton = 32.8 x 2.60/ac	85.28
Total Cost/ton	$528.38

One ton 82-0-0 contains 2000 x .82 = 1640 lb of N
Therefore, the cost per pound of N applied is
$\frac{\$528.38}{1640\ lb}$ = 32.2¢

D. Phosphate Fertilizer applied with Seeder

Purchase 12-51-0 fertilizer in December for spring application.

	$/ton
Cost of Product in December (Laid-in)	$318.00
Trucking to Field	13.89
Storage	7.53
Interest (5 months)	15.90
Application (part of seeding operation)	0
Total Cost/ton	$355.32

One ton of 12-51-0 contains 240 lb of N and 1020 lbs P_2O_5.
If N is worth 30¢ per pound then the value of the N in 12-51-0 is $72.00
The value of the P_2O_5 is 355.32 - 72.00 = $283.32
The value of P_2O_5 per pound is $\frac{283.32}{1020\ lb}$ = 27.8¢

These examples indicate different total costs of fertilizer depending on the method of application. **However, fertilizer placement methods affect fertilizer efficiency and seedbed condition.** Choice of application method should not be based solely on cost since extra returns may compensate for extra costs.

The machinery costs used in the above calculations include an estimate of fuel, oil, repairs, depreciation, interest on investment, insurance and labor as published in Saskatchewan Agriculture's Farm Machinery Custom and Rental Rate Guide. The actual out of pocket expense (variable costs) for farmers that own their own equipment will be less than the costs indicated. In the short run, only variable costs need to be considered. However, in the long run, all costs must be covered.

Timing Fertilizer Purchases

For those farmers who apply fertilizer in the spring, the break even prices can be determined to compare fall purchase with spring purchase. Storage costs and interest on the fertilizer cost must be considered in addition to the difference in fertilizer prices at the two times.

Example:

A farmer can purchase 12-51-0 fertilizer in November 1985 at a cost of $300 per ton. His estimated on farm storage cost is $5.00 per ton. He can invest money at 10%. With these figures, the break even price for spring purchase can be determined as follows:

	$/ton
Cost of Fertilizer in November 1985	300
Storage costs	5
Interest $300 x 10% x $\frac{6\ months}{12\ months}$	15
Break even price in April 1986	$320

This indicates that if fertilizer can be purchased in April 1986, for $320/ton or less, then spring purchase is best. If the estimated April price is more than $320/ton, then fall purchase is best.

Discounting Grain Prices

Farmers should discount the price of grain used in calculating returns from fertilizer use because the additional production must be stored longer and is worth less than grain sold earlier. Yield increases from fertilizer use should be considered the last portion of the crop sold. There may be a 12-15 month delay between the planting of a crop and the time that the last part of the crop is sold. The delay is about 18 months for the portion of the crop sales realized by way of final payments from the Canadian Wheat Board.

The following example illustrates the method of discounting the price of grain for the time period between planting and final sale.

Interest rate	10%
Time lag	15 months
Expected price of wheat	$4.25 per bushel
Discount amount=$4.25 x 10% x $\frac{15\ months}{12\ months}$	=$0.53

Profitable Fertilizer Use

Yield response to fertilizer nutrients are dependent on the other nutrients being adequate. For example, the expected yield increase for adding the nutrient nitrogen will not necessarily apply if say sulfur or phosphate is deficient.

a) Nitrogen

Soil Test recommendations from the Saskatchewan Soil Testing Laboratory and expected yield increase tables are based on average or typical conditions. Actual yield response can vary significantly from the average because of environmental factors. The effect on yield by using nitrogen fertilizer is greatly influenced by available moisture. The more moisture available, the more nitrogen fertilizer that can be economically applied. When there is a shortage of moisture, then lower levels of nitrogen fertilizer are justified.

Unfortunately, it is difficult to predict what moisture will be available during the growing season. Growing season rainfall is often inadequate in many years for maximum yields. The relative frequency when available moisture limits crop yield is indicated below:

Soil Zone	Fallow Crop	Stubble Crop
Brown	75%	80%
Dark Brown	43%	52%
Black, Gray-Black, Gray	18%	25%

This indicates that some stored soil moisture is often necessary. Soil scientists have established guidelines for stored soil moisture which will result in stubble cropping having a reasonable chance of success.

	Soil Zone		
Soil Texture	Brown	Dark Brown	Black Gray Black & Gray
	Depth of Soil Moisture (inches)		
Coarse (sands & sandy loams)	48	36	24
Medium (loams & clay loams)	36	24	18
Fine (clay & heavy clay)	24	18	12
Available water	4"	3"	2"

b) Phosphorous

The effect of phosphate fertilizer on yield is less dependent on available moisture than is the case with nitrogen. Factors such as early seeding, cold soil, plus a low level of available phosphate in the soil will tend to give the largest yield response to phosphate fertilizer. Later seeding, warm soil and a high level of available phosphate in the soil will tend to give a smaller yield response to phosphate fertilizer. However, most Saskatchewan soils are deficient in phosphate. Further, phosphate fertilizer will increase the speed of maturity of crops by up to seven days in wheat and fourteen days for barley.

The annual variation in phosphate response is indicated by research on Sceptre Clay soil. The yield increase of wheat due to an 18 lb/acre application of P_2O_5 over an 18 year period averaged 5.6 bu/acre. However, the yield increase varied from a low of 2 bu/acre to a high of 12 bu/acre. Using a P_2O_5 cost of 30¢/lb, and a wheat price of $3.75 per bushel, the following cost-benefit relationship exists from this research.

Yield Increase	Value of Yield Increase (Wheat $3.75/bu)	Cost of P_2O_5 ($.30/lb)	Return Over Cost
	($/ac)	($/ac)	($/ac)
Average (5.6 bu/ac)	21.00	5.40	15.60
Lowest (2.0 bu/ac)	7.50	5.40	2.10
Highest (12.0 bu/ac)	45.00	5.40	39.60

In the above table even under the worst possible circumstance shows that the use of phosphate fertilizer at moderate rates on Sceptre clay soil will return more than the cost.

c) Sulfur

Profitable yield response to sulfur fertilizer will occur on sulfur deficient soils in much the same manner as has been indicated for nitrogen and phosphate deficient soils. Most Saskatchewan soils are not deficient in sulfur. Soil tests will indicate if sulfur is required.

Expected Yield Increases

a) Nitrogen Fertilizer

The Saskatchewan Soil Testing Laboratory provides soil test reports which indicate the expected yield increase from varying levels of nitrogen fertilizer. The expected yield increase will vary from field to field and depend on the available nitrogen in the soil as determined by a soil test. Only by doing individual soil tests, can expected yield increase tables be meaningful.

The Saskatchewan Soil Testing Laboratory has prepared expected yield increase tables for several different crops for each of the three major soil zones in the province. For each possible level of available nitrogen in the soil, the expected increase in yield for added amounts of nitrogen fertilizer is indicated. These tables are reproduced in Appendix A for wheat, barley, flax and rapeseed.

By applying the cost of the nitrogen and the price of the grain to the physical data, the most profitable level of nitrogen fertilizer use can be determined. This is indicated in the following

tables derived from the tables in Appendix A. **Note that the yield increases are based on 21-25 pounds of available nitrogen in the soil. As previously indicated only a soil test can determine the actual level of nitrogen in the soil. Yield increase factors will vary with the level of N in the soil.**

Table 3 **Brown Soils - Wheat on Stubble**
Expected Yield Increase (bu/ac)
(21-25 lb of soil N)

Fertilizer N Applied (lb/ac)	Units of N Fertilizer Applied (lb/ac)	Cost of N Fertilizer Units at $.32/lb ($/ac)	Expected Yield Increase (bu/ac)	Yield Increase Per Unit of N Fertilizer (bu/ac) ($/ac)	Value of Yield Increase at $3.75/bu ($/ac)	Value of Yield Increase at $5.00/bu
0	0	0	0	0	0	0
10	10	3.20	1.8	1.8	6.75	9.00
20	10	3.20	3.3	1.5	5.62	7.50
30	10	3.20	4.5	1.2	4.50*	6.00
40	10	3.20	5.3	0.8	3.00	4.00*
50	10	3.20	5.8	0.5	1.88	2.50
60	10	3.20	5.8	0	0	0
70	10	3.20	5.8	0	0	0
80	10	3.20	5.8	0	0	0
100	20	6.40	5.8	0	0	0
120	20	6.40	5.8	0	0	0

With a wheat price of $3.75 per bushel, the most profitable level of nitrogen fertilizer would be 30 pounds of actual nitrogen per acre (65 lbs per acre of 46-0-0).

The added returns from applying 30 pounds of actual N would be 4.5 bu/ac x $3.75/bu or $16.88 at a cost of 30 lb/ac x $.32/lb or $9.60. The return over costs would be $16.88 - 9.60 = $7.28/acre. On a quarter section, the extra net income would be $7.28/ac x 160 ac = $1165. This equivalent to a rate of return on investment of approximately 175%.

If the price of wheat was $5.00 per bushel, it would be profitable to add 40 pound of actual N (equivalent to 87 lb per acre of 46-0-0). The return over costs would be (5.3 bu x $5.00) - (40 lb/acre x $.32/lb) = $26.50 - 12.80 = $13.70/acre.

For situations with different fertilizer or grain prices, the most profitable level of nitrogen fertilizer application could be determined by changing the figures accordingly. For soil test results with different levels of available soil N, the table in Appendix A could be used to determine the yield response for different levels of N fertilizer.

Table 4 **Dark Brown Soils - Wheat on Stubble**
Expected Yield Increase (bu/ac)
(21-25 lb of soil N)

Fertilizer N Applied (lb/ac)	Units of N Fertilizer Applied (lb/ac)	Cost of N Fertilizer Units at $.32/lb ($/ac)	Expected Yield Increase (bu/ac)	Yield Increase Per Unit of N Fertilizer (bu/ac) ($/ac)	Value of Yield Increase at $3.75/bu ($/ac)	Value of Yield Increase at $5.00/bu
0	0	0	0	0	0	0
10	10	3.20	2.5	2.5	9.38	12.50
20	10	3.20	4.7	2.2	8.25	11.00
30	10	3.20	6.5	1.8	6.75	9.00
40	10	3.20	8.0	1.5	5.62	7.50
50	10	3.20	9.2	1.2	4.50*	6.00
60	10	3.20	10.0	0.8	3.00	4.00*
70	10	3.20	10.5	0.5	1.88	2.50
80	10	3.20	10.5	0	0	0
100	20	6.40	10.5	0	0	0
120	20	6.40	10.5	0	0	0

The most profitable level of fertilizer N use with a wheat price of $3.75 per bushel would be 50 pounds per acre of actual N (equivalent to 109 lbs of 46-0-0). The total extra returns would be 9.2 bu/ac x $3.75/bu or $34.50 at a cost of 50 lb/ac x $.32/lb or $16.00. The return over costs would be $34.50 - 16.00 = $18.50/acre. On a quarter section, the extra net income would be $18.50 x 160 ac = $2960. This is equivalent to a rate of return on investment of approximately 215%.

If the price of wheat was $5.00 per bushel, it would pay to add 60 lbs of actual N (equivalent to 130 lb per acre of 46-0-0). The return over costs would be (10.0 bu/ac x $5.00) - (60 lb/ac x $.32/lb) = $50.00 - 19.20 = $30.80/ac

Table 5

Black & Gray Soils - Wheat on Stubble
Expected Yield Increase (bu/ac)

(21-25 lb of soil N)

Fertilizer N Applied (lb/ac)	Units of N Fertilizer Applied (lb/ac)	Cost of N Fertilizer Units at $.32/lb ($/ac)	Expected Yield Increase (bu/ac)	Yield Increase Per Unit of N Fertilizer (bu/ac)	Value of Yield Increase at $3.75/bu ($/ac)	Value of Yield Increase at $5.00/bu ($/ac)
0	0	0	0	0	0	0
10	10	3.20	3.3	3.3	12.38	16.50
20	10	3.20	6.3	3.0	11.25	15.00
30	10	3.20	9.0	2.7	10.12	13.50
40	10	3.20	11.3	2.3	8.62	11.50
50	10	3.20	13.3	2.0	7.50	10.00
60	10	3.20	15.0	1.7	6.37	8.50
70	10	3.20	16.3	1.7	4.87	6.50
80	10	3.20	17.3	1.0	3.75*	5.00*
100	20	6.40	18.3	1.0	3.75	5.00
120	20	6.40	18.3	0	0	0

The most profitable level of fertilizer N use with a wheat price of $3.75 per bushel would be 80 lb per acre of actual N (equivalent to 174 lbs of 46-0-0). The total extra return would be 17.3 bu/ac x $3.75/bu or $64.88 at a cost of 80 lb/ac x $.32 or $25.60/acre. The return over costs would be $64.88 - $25.60/acre or $39.28. On a quarter section, to extra net increase would be $39.28 x 160 ac = $6285. This is equivalent to a rate of return on investment of approximately 250%.

If the price of wheat was $5.00 per bushel, it would pay to add the same 80 lbs of actual N. The return over costs would be (17.3 bu/ac x $5.00) - (80 lb/ac x $.32/lb) = $86.50 - 25.60 = $60.90/acre.

Moisture Factor

Saskatchewan Soil Testing Laboratory recommendations for nitrogen fertilizer are now given for three possible soil moisture conditions. These are dry, normal and wet. Expected yield increases are given only for normal moisture conditions. Probable soil moisture conditions for the growing season can be partially assessed prior to seeding by determining the depth of moisture in the soil.

Soil test recommendations for nitrogen are based on nitrogen levels that should return $1.50 in extra income for each $1.00 of fertilizer expense. This ratio allows for the risk of less than optimum conditions in the use of fertilizer. However, economic theory suggests that maximum profits are obtained when $1.00 of extra fertilizer expense just returns $1.00 of extra income. By using the expected yield increase tables in conjunction with fertilizer and grain prices, farmers can select a fertilizer application rate that meets their own profit objective.

The Saskatchewan Soil Testing Laboratory have expected yield increase tables for all major crops

in the various soil zones. As indicated previously, the schedule of yield increase is dependent on the actual nitrogen in the soil. Only by soil testing can a farmer accurately use expected yield increase tables in planning fertilizer use. For nitrogen fertilizer a soil test is required every year since available soil nitrogen can vary greatly from one year to the next.

Nitrogen soil testing is most common on stubble fields. However, summerfallow fields can also be deficient in nitrogen and can often benefit from the addition of extra nitrogen fertilizer. Since summerfallow fields are often high in available moisture prior to seeding, the yield response from nitrogen fertilizer is likely to be quite high, if soil nitrogen is deficient. As for stubble fields, a soil test is necessary to make a sound assessment of the amount of nitrogen fertilizer to apply.

Yield response to N fertilizer will vary between crops. Certain crops such as barley often give a greater economic response to fertilizer than wheat.

b) **Phosphate Fertilizer**

Most Saskatchewan soils are deficient in phosphorus and will give a significant yield increase from tne application of phosphate fertilizer.

Soil testing is desirable to determine the available phosphorus in the soil. Additional phosphate fertilizer can then be applied to meet any deficiencies. Soil testing may not be required every year for phosphate since the level of available soil phosphate in any one field does not vary a great deal from year to year.

Expected yield increase tables have been prepared for the major crops grown in Saskatchewan. The yield increases from phosphate application depends on the available soil phosphate. Expected yield increases tables for wheat, barley, flax, rape and oats are reproduced in Appendix B.

The following yield response is based on 15 pounds of available soil phosphate.

Table 6:

Phosphate Fertilizer - Wheat (All Soils)
Expected Yield Increase (bu/ac)

Fertilizer P_2O_5 Applied (lb/ac)	Units of P_2O_5 Fertilizer Applied (lb/ac)	Cost of P_2O_5 Fertilizer Units at $.28/lb ($/ac)	Expected Yield Increase (bu/ac)	Yield Increase Per Unit of P_2O_5 Fertilizer (bu/ac)	Value of Yield Increase at $3.75/bu ($/ac)	Value of Yield Increase at $5.00/bu ($/ac)
0	0	0	0	0	0	0
10	10	2.80	3.0	3.0	11.25	15.00
20	10	2.80	5.1	2.1	7.88	10.50
30	10	2.80	6.3	1.2	4.50*	6.00**
40	10	2.80	6.8	.5	1.88	2.50
50	10	2.80	7.0	.2	.75	1.00

With wheat prices of $3.75 per bushel, the most profitable level of phosphate application is 30 lb/acre (equivalent to 59 lb/ac of 11-51-0 fertilizer). This would typically result in a 6.3 bu/acre yield increase. The return over costs would be (6.3 bu/ac x $3.75/bu) - (30 lb/ac x $.28/lb) = $23.63 - 8.40 = $15.23 per acre. On a quarter section, the net return would be 160 acres x $15.23 = $2437. This is equivalent to a rate of return on investment of approximately 280%.

With wheat prices of $5.00 per bushel, the same 30 lb level of phosphate application would be the most profitable. This would result in a net return per acre of (6.3 bu/ac x $5.00/bu) - 30 lb/ac x $.28/lb) = $31.50 - 8.40 = $23.10. On a quarter section it would result in a net return of $3696.

Fertilizing at Less than Recommended Rates

Farmers may apply fertilizer at less than recommended or optimum rates. This may be done to minimize risk or to stay within an overall budget for fertilizer. Fertilizing at less than recommended rates will lower overall profits in the long run. It would normally pay to borrow capital if funds were limited.

A principle called "equal marginal returns" can be used to ensure that the greatest possible profit is realized from fertilizer use when less than recommended rates of fetilizer are used. In order to illustrate this principle, the following example is used.

Example

The farmer is limited to the purchase of 28,000 pounds of nitrogen fertilizer (actual N) at a price of $.30 per pound for a total expenditure of $8,400. He can allocate the N fertilizer between 200 acres of canola, 300 acres of wheat, and 400 acres of barley. Based on soil tests results and grain prices as indicated, tables 7 and 8 can be used to select the best allocation of fertilizer among the crop choices.

Table 7

Equal Marginal Returns Analysis

Nitrogen Applied (lb/ac)	10	20	30	40	50	60	70	80	90	100
Yield increase (canola) (bu/ac)	1.1	2.1	3.0	3.8	4.4	4.9	5.3	5.6	5.6	5.6
Added yield (bu/ac)	1.1	1.0	.9	.8	.6	.5	.4	.3	0	0
Added return ($/ac) (at $6/bu)	6.60	6.00	5.40	4.80	3.60	3.00	2.40	1.80	0	0
Yield increase (wheat) (bu/ac)	2.7	5.0	7.0	8.7	10.0	11.1	11.7	12.0	12.0	12.0
Added yield (bu/ac)	2.7	2.3	2.0	1.7	1.3	1.1	.6	.3	0	0
Added return ($/ac) (at $4.00/bu)	10.80	9.20	8.00	6.80	5.20	4.40	2.40	1.20	0	0
Yield increase (barley) (bu/ac)	3.8	7.2	10.0	12.2	14.0	15.2	15.8	15.8	15.8	15.8
Added yield (bu/ac)	3.8	3.4	2.8	2.2	1.8	1.2	.6	0	0	0
Added return ($/ac) at $2.00/bu	7.60	6.80	5.60	4.40	3.60	2.40	1.20	0	0	0

In table 7, the greatest returns from the first 10 pounds of N fertilizer is from wheat with an extra return of $10.80 per acre. Since there are 300 acres of wheat to fertilizer, this would require 3000 pounds in total nitrogen (indicated in table 8). The second 10 pound unit of N fertilizer is applied to wheat with a return of $9.20 per acre. This requires 3000 total pounds on the 300 acres. The cumulative fertilizer requirement is now 6000 pounds (table 8). This procedure is carried on until all of the 28000 pounds of N fertilizer are comitted in the most profitable manner (table 8).

Table 8

Allocation of 10 lb Increments of Nitrogen According to Added Returns Given in Table 7 to maximum of 28000 Pounds

Allocation Step	Added Return/acre	Crop	Acres	Pounds Allocated This Step	Total Pounds Allocated
1	10.80	Wheat	300	3000	3000
2	9.20	Wheat	300	3000	6000
3	8.00	Wheat	300	3000	9000
4	7.60	Barley	400	4000	13000
5	6.80	Barley	400	4000	17000
6	6.80	Wheat	300	3000	20000
7	6.60	Canola	200	2000	22000
8	6.00	Canola	200	2000	24000
9	5.60	Barley	400	4000	28000

Note that in allocating fertilizer, the fertilizer should not be added beyond the point where the added fertilizer cost of $3.00 per are (10 lb/ac x $.30/lb) exceeds the added return for any crop as indicated in table 7.

The N fertilizer allocation is as follows:

Canola: 20 lb/acre x 200 acres =	4000 lb
Wheat: 40 lb/acre x 300 acres =	12000 lb
Barley: 30 lb/acre x 400 acres =	12000 lb
Total N fertilizer	28000 lb

The return above fertilizer costs would be as follows:

Canola	
(2.1 bu/ac x $6.00/bu x 200 ac) - (200 ac x 20 lb/ac x $.30/lb) =	$1,320
Wheat	
(8.7 bu/ac x $4.00/bu x 300 ac) - (300 ac x 40 lb/ac x $.30/lb) =	6,840
Barley	
(10.0 bu/ac x $2.00/bu x 400 ac) - (400 ac x 30 lb/ac x $.30/lb) =	4,400
Total Net Returns	$12,560

If expenditues on fertilizer were not limited then it would have paid to add N fertilizer until the added fertilizer cost was equal to the added crop income for each crop. The fertilizer allocation would have been as follows:

Canola: 60 lb/ac x 200 ac =	12,000 lb
Wheat: 60 lb/ac x 300 ac =	18,000 lb
Barley: 50 lb/ac x 400 ac =	20,000 lb
Total N fertilizer	50,000 lb

This would have required 50,000 pounds of fertilizer as compared to 28,000 pounds.

The return above fertilizer costs would be as follows:

Canola	
(4.9 bu/ac x $6.00/bu x 200 ac) - (200 ac x 60 lb/ac x $.30/lb) =	2,280
Wheat	
(11.1 bu/ac x $4.00/bu x 300 ac) - (300 ac x 60 lb/ac x $.30/lb) =	7,920
Barley	
(14.0 bu/ac x $2.00/bu x 400 ac) - (400 ac x 50 lb/ac x $.30/lb) =	5,200
	$15,400

This indicates that a further profit of $2,840 is potentially lost because fertilizer is not applied at the optimum rates. However, if capital is limited, the fertilizer input should be allocated according to the procedure indicated by the equal marginal returns principle. This ensures that the greatest profit is realized from the resources used.

Fertilizer Decisions on Leased Land

Profitable fertilizer decisions can be different on owned land as compared to leased land. If land is rented on say a one third: two third crop share basis and the tenant pays all fertilizer costs, then the tenant receives only two thirds of the added returns. This means that the amount of fertilizer used that will result in the greatest profit will be lower on the leased land as compared to owned land where the owner receives the entire crop.

Fertilizer use on land leased on a crop share basis could be justified at the same level as on owned land if the landlord paid a share of the fertilizer costs. The landlord's percentage share of fertilizer costs could be the same as his share of the crop.

Fertilizer decisions on land leased on a cash rental basis will be the same as on owned land since the farmer receives the entire crop in both cases.

Summary

Fertilizer use is one of the many management decisions farmers face each year. **Sound decisions can best be made after a soil test has been properly interpreted.**

Changing economic circumstances, in particular , changing fertilizer prices and grain prices, affect the most profitable level of fertilizer use. Lower grain prices and/or higher fertilizer prices would tend to reduce fertilizer use to achieve greatest profits. While higher grain prices and lower fertilizer prices would tend to increase fertilizer use to achieve greatest profits.

Fertilizer use should not be looked at as an either/or decision. For example, a decline in grain prices may justify a reduction in the amount of fertilizer use, but it would not necessarily mean that fertilizer use should be eliminated altogether.

The economics of fertilizer use for stubble crops should be considered on a regional context, considering moisture supply. Some farmers in the Brown and Dark Brown soil zones may find that stubble cropping does not pay at the present time because of low grain prices. However, if stubble cropping is profitable, then applying fertilizer at recommended rates is justified.

Where moisture is adequate, stubble cropping is likely profitable. However, for many farmers, stubble cropping does not pay because of improper fertilization. Farmers who grow crops on stubble land and are considering reducing the use of fertilizer below soil test recommendations or eliminating its use altogether may find it more profitable to eliminate stubble cropping entirely. Careful financial planning is required to determine the best crop rotation and intensity of fertilizer use.

With the high return on investment in fertilizer use, farmers will almost always find it beneficial even if it is necessary to borrow money to purchase fertilizer. The extra returns from crop production will greatly exceed interest on borrowed capital.

APPENDIX A

Expected Yield Increase Tables for Nitrogen

Expected Yield Increase Information for Dryland and Irrigated Crops Grown in Saskatchewan

1982 - 1983

Prepared for use in the Saskatchewan Soil Testing Laboratory by the Fertility Committee of the Saskatchewan Advisory Council on Soils and Agronomy (an advisory body to the Minister of Agriculture).

Note: The yield increase tables for nitrogen relate to "normal" moisture conditions only.

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Crop	Nitrogen
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Barley	4 - 8
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WHEAT (Spring, winter, utility, soft and durum)

BROWN SOIL ZONE - MOISTURE DEFICIT INDEX 17

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	2.5	4.7	6.5	8.0	9.2	10.0	10.5	10.5	10.5	10.5	10.5	10.5	10.5
6-10	2.3	4.3	6.0	7.3	8.3	9.0	9.3	9.3	9.3	9.3	9.3	9.3	9.3
11-15	2.2	4.0	5.5	6.7	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
16-20	2.0	3.7	5.0	6.0	6.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
21-25	1.8	3.3	4.5	5.3	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
26-30	1.7	3.0	4.0	4.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
31-35	1.5	2.7	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
36-40	1.3	2.3	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
41-45	1.2	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
46-50	1.0	1.7	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
51-55	0.8	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
56-60	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
61-65	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
66-70	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
71-75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76-80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
81-85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86-90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91-95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

WHEAT (Spring, winter, utility, soft and durum)

DARK BROWN ZONE - MOISTURE DEFICIT INDEX 13

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	3.2	6.0	8.5	10.7	12.5	14.0	15.2	16.0	16.0	16.0	16.0	16.0	16.0
6-10	3.0	5.7	8.0	10.0	11.7	13.0	14.0	14.7	14.7	14.7	14.7	14.7	14.7
11-15	2.8	5.3	7.5	9.3	10.8	12.0	12.8	13.3	13.3	13.3	13.3	13.3	13.3
16-20	2.7	5.0	7.0	8.7	10.0	11.0	11.7	12.0	12.0	12.0	12.0	12.0	12.0
21-25	2.5	4.7	6.5	8.0	9.2	10.0	10.5	10.5	10.5	10.5	10.5	10.5	10.5
26-30	2.3	4.3	6.0	7.3	8.3	9.0	9.3	9.3	9.3	9.3	9.3	9.3	9.3
31-35	2.2	4.0	5.5	6.7	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
36-40	2.0	3.7	4.5	6.0	6.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
41-45	1.8	3.3	4.0	5.3	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
46-50	1.7	3.0	3.5	4.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
51-55	1.5	2.7	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
56-60	1.3	2.3	2.5	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
61-65	1.2	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
66-70	1.0	1.7	1.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
71-75	0.8	1.3	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
76-80	0.7	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
81-85	0.5	0.5	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
86-90	0.3	0.3	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
91-95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

WHEAT (Spring, winter, utility, soft and durum)

THIN & THICK, BLACK, GRAY BLACK, & GRAY - MOISTURE DEFICIT INDEX 8

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	160	220
0-5	4.0	7.7	11.0	14.0	16.7	19.0	21.0	22.7	25.0	26.0	26.0	26.0	26.0
6-10	3.8	7.3	10.5	13.3	15.8	18.0	19.8	21.3	23.3	23.3	23.3	23.3	23.3
11-15	3.7	7.0	10.0	12.7	15.0	17.0	18.7	20.0	21.7	21.7	21.7	21.7	21.7
16-20	3.5	6.7	9.5	12.0	14.2	16.0	17.5	18.7	20.0	20.0	20.0	20.0	20.0
21-25	3.3	6.3	9.0	11.3	13.3	15.0	16.3	17.3	18.3	18.3	18.3	18.3	18.3
26-30	3.2	6.0	8.5	10.7	12.5	14.0	15.2	16.0	16.0	16.0	16.0	16.0	16.0
31-35	3.0	5.7	8.0	10.0	11.7	13.0	14.0	14.7	14.7	14.7	14.7	14.7	14.7
36-40	2.8	5.3	7.5	9.3	10.8	12.0	12.8	13.3	13.3	13.3	13.3	13.3	13.3
41-45	2.7	5.0	7.0	8.7	10.0	11.0	11.7	12.0	12.0	12.0	12.0	12.0	12.0
46-50	2.5	4.7	6.5	8.0	9.2	10.0	10.5	10.5	10.5	10.5	10.5	10.5	10.5
51-55	2.3	4.3	6.0	7.3	8.3	9.0	9.3	9.3	9.3	9.3	9.3	9.3	9.3
56-60	2.2	4.0	5.5	6.7	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
61-65	2.0	3.7	5.0	6.0	6.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
66-70	1.8	3.3	4.5	5.3	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
71-75	1.7	3.0	4.0	4.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
76-80	1.5	2.7	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
81-85	1.3	2.3	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
86-90	1.2	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
91-95	1.0	1.7	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
96-100	0.8	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
101-105	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
106-110	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
111-115	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

WHEAT (Spring, winter, utility, soft and durum)

IRRIGATION (All zones) MOISTURE DEFICIT INDEX I

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	5.2	10.0	14.5	18.7	22.5	26.0	29.2	32.0	36.7	40.0	42.0	42.0	42.0
6-10	5.0	9.7	14.0	18.0	21.7	25.0	28.0	30.7	35.0	38.0	39.7	39.7	39.7
11-15	4.8	9.3	13.5	17.3	20.8	24.0	26.8	29.3	33.3	36.0	37.3	37.3	37.3
16-20	4.7	9.0	13.0	16.7	20.0	23.0	25.7	28.0	31.7	34.0	35.0	35.0	35.0
21-25	4.5	8.7	12.5	16.0	19.2	22.0	24.5	26.7	30.0	32.0	32.7	32.7	32.7
26-30	4.3	8.3	12.0	15.3	18.3	21.0	23.3	25.3	28.3	30.0	30.0	30.0	30.0
31-35	4.2	8.0	11.5	14.7	17.5	20.0	22.2	24.0	26.7	28.0	28.0	28.0	28.0
36-40	4.0	7.7	11.0	14.0	16.7	19.0	21.0	22.7	25.0	26.0	26.0	26.0	26.0
41-45	3.8	7.3	10.5	13.3	15.8	18.0	19.8	21.3	23.3	24.0	24.0	24.0	24.0
46-50	3.7	7.0	10.0	12.7	15.0	17.0	18.7	20.0	21.7	21.7	21.7	21.7	21.7
51-55	3.5	6.7	9.5	12.0	14.2	16.0	17.5	18.7	20.0	20.0	20.0	20.0	20.0
56-60	3.3	6.3	9.0	11.3	13.3	15.0	16.3	17.3	18.3	18.3	18.3	18.3	18.3
61-65	3.2	6.0	8.5	10.7	12.5	14.0	15.2	16.0	16.7	16.7	16.7	16.7	16.7
66-70	3.0	5.7	8.0	10.0	11.7	13.0	14.0	14.7	14.7	14.7	14.7	14.7	14.7
71-75	2.8	5.3	7.5	9.3	10.8	12.0	12.8	13.3	13.3	13.3	13.3	13.3	13.3
76-80	2.7	5.0	7.0	8.7	10.0	11.0	11.7	12.0	12.0	12.0	12.0	12.0	12.0
81-85	2.5	4.7	6.5	8.0	9.2	10.0	10.5	10.7	10.7	10.7	10.7	10.7	10.7
86-90	2.3	4.3	6.0	7.3	8.3	9.0	9.3	9.3	9.3	9.3	9.3	9.3	9.3
91-95	2.2	4.0	5.5	6.7	7.5	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2
96-100	2.0	3.7	5.0	6.0	6.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
101-105	1.8	3.3	4.5	5.3	5.8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
106-110	1.7	3.0	4.0	4.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
111-115	1.5	2.7	3.5	4.0	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
116-120	1.3	2.3	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
121-125	1.2	2.0	2.5	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
126-150	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

BARLEY

BROWN SOIL ZONE - MOISTURE DEFICIT INDEX 17

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	160	220
0-5	4.4	8.2	11.5	14.3	16.6	18.3	19.5	20.2	20.2	20.2	20.2	20.2	20.2
6-10	4.1	7.7	10.8	13.3	15.3	16.8	17.7	18.1	18.1	18.1	18.1	18.1	18.1
11-15	3.8	7.2	10.0	12.2	14.0	15.2	15.8	15.8	15.8	15.8	15.8	15.8	15.8
16-20	3.6	6.6	9.2	11.2	12.6	13.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0
21-25	3.3	6.1	8.4	10.1	11.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
26-30	3.1	5.6	7.6	9.1	10.0	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
31-35	2.8	5.1	6.8	8.0	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
36-40	2.5	4.5	6.0	6.9	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
41-45	2.3	4.0	5.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
46-50	2.0	3.5	4.4	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
51-55	1.7	2.9	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
56-60	1.5	2.4	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
61-65	1.2	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
66-70	0.9	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
71-75	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
76-80	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
81-85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86-90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91-95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BARLEY

DARK BROWN ZONE - MOISTURE DEFICIT INDEX 13

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	5.4	10.3	14.7	18.6	21.9	24.7	26.9	28.7	30.6	30.6	30.6	30.6	30.6
6-10	5.2	9.8	13.9	17.5	20.6	23.1	25.1	26.6	27.9	27.9	27.9	27.9	27.9
11-15	4.9	9.3	13.1	16.4	19.2	21.5	23.2	24.4	24.4	24.4	24.4	24.4	24.4
16-20	4.6	8.8	12.3	15.4	17.9	19.9	21.4	22.3	22.3	22.3	22.3	22.3	22.3
21-25	4.4	8.2	11.5	14.3	16.6	18.3	19.5	20.2	20.2	20.2	20.2	20.2	20.2
26-30	4.1	7.7	10.8	13.3	15.3	16.8	17.7	18.1	18.1	18.1	18.1	18.1	18.1
31-35	3.8	7.2	10.0	12.2	14.0	15.2	15.8	15.8	15.8	15.8	15.8	15.8	15.8
36-40	3.6	6.6	9.2	11.2	12.6	13.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0
41-45	3.3	6.1	8.4	10.1	11.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
46-50	3.1	5.6	7.6	9.1	10.0	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
51-55	2.8	5.1	6.8	8.0	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
56-60	2.5	4.5	6.0	6.9	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
61-65	2.3	4.0	5.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
66-70	2.0	3.5	4.4	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
71-75	1.7	2.9	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
76-80	1.5	2.4	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
81-85	1.2	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
86-90	0.9	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
91-95	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
96-100	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BARLEY

THIN & THICK, BLACK, GRAY BLACK, & GRAY - MOISTURE DEFICIT INDEX 8

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	6.8	13.0	18.7	23.8	28.5	32.6	36.2	39.2	43.8	46.2	46.2	46.2	46.2
6-10	6.5	12.4	17.9	22.8	27.2	31.0	34.3	37.1	41.1	43.0	43.0	43.0	43.0
11-15	6.2	11.9	17.1	21.7	25.8	29.4	32.5	35.0	38.5	39.8	39.8	39.8	39.8
16-20	6.0	11.4	16.3	20.7	24.5	27.8	30.6	32.9	35.8	35.8	35.8	35.8	35.8
21-25	5.7	10.9	15.5	19.6	23.2	26.3	28.8	30.8	33.2	33.2	33.2	33.2	33.2
26-30	5.4	10.3	14.7	18.6	21.9	24.7	26.9	28.7	30.6	30.6	30.6	30.6	30.6
31-35	5.2	9.8	13.9	17.5	20.6	23.1	25.1	26.6	27.9	27.9	27.9	27.9	27.9
36-40	4.9	9.3	13.1	16.4	19.2	21.5	23.2	24.4	24.4	24.4	24.4	24.4	24.4
41-45	4.6	8.8	12.3	15.4	17.9	19.9	21.4	22.3	22.3	22.3	22.3	22.3	22.3
46-50	4.4	8.2	11.5	14.3	16.6	18.3	19.5	20.2	20.2	20.2	20.2	20.2	20.2
51-55	4.1	7.7	10.8	13.3	15.3	16.8	17.7	18.1	18.1	18.1	18.1	18.1	18.1
56-60	3.8	7.2	10.0	12.2	14.0	15.2	15.8	15.8	15.8	15.8	15.8	15.8	15.8
61-65	3.6	6.6	9.2	11.2	12.6	13.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0
66-70	3.3	6.1	8.4	10.1	11.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
71-75	3.1	5.6	7.6	9.1	10.0	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
76-80	2.8	5.1	6.8	8.0	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
81-85	2.5	4.5	6.0	6.9	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
86-90	2.3	4.0	5.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
91-95	2.0	3.5	4.4	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
96-100	1.7	2.9	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
101-105	1.5	2.4	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
106-110	1.2	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
111-115	0.9	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
116-120	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
121-125	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BARLEY

IRRIGATION (All zones) MOISTURE DEFICIT INDEX 1

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	8.6	16.7	24.2	31.2	37.7	43.7	49.1	54.0	62.2	68.3	72.3	72.3	72.3
6-10	8.3	16.1	23.4	30.2	36.4	42.1	47.3	51.9	59.6	65.2	68.6	68.6	68.6
11-15	8.1	15.6	22.6	29.1	35.1	40.5	45.4	49.8	56.9	62.0	64.9	64.9	64.9
16-20	7.8	15.1	21.8	28.1	33.8	38.9	43.6	47.7	54.3	58.8	61.3	61.3	61.3
21-25	7.5	14.6	21.0	27.0	32.4	37.3	41.7	45.6	51.7	55.7	57.6	57.6	57.6
26-30	7.3	14.0	20.3	25.9	31.1	35.8	39.9	43.4	49.0	52.5	53.9	53.9	53.9
31-35	7.0	13.5	19.5	24.9	29.8	34.2	38.0	41.3	46.4	49.3	49.3	49.3	49.3
36-40	6.8	13.0	18.7	23.8	28.5	32.6	36.2	39.2	43.8	46.2	46.2	46.2	46.2
41-45	6.5	12.4	17.9	22.8	27.2	31.0	34.3	37.1	41.1	43.0	43.0	43.0	43.0
46-50	6.2	11.9	17.1	21.7	25.8	29.4	32.5	35.0	38.5	39.8	39.8	39.8	39.8
51-55	6.0	11.4	16.3	20.7	24.5	27.8	30.6	32.9	35.8	35.8	35.8	35.8	35.8
56-60	5.7	10.9	15.5	19.6	23.2	26.3	28.8	30.8	33.2	33.2	33.2	33.2	33.2
61-65	5.4	10.3	14.7	18.6	21.9	24.7	26.9	28.7	30.6	30.6	30.6	30.6	30.6
66-70	5.2	9.8	13.9	17.5	20.6	23.1	25.1	26.6	27.9	27.9	27.9	27.9	27.9
71-75	4.9	9.3	13.1	16.4	19.2	21.5	23.2	24.4	24.4	24.4	24.4	24.4	24.4
76-80	4.6	8.8	12.3	15.4	17.9	19.9	21.4	22.3	22.3	22.3	22.3	22.3	22.3
81-85	4.4	8.2	11.5	14.3	16.6	18.3	19.5	20.2	20.2	20.2	20.2	20.2	20.2
86-90	4.1	7.7	10.8	13.3	15.3	16.8	17.7	18.1	18.1	18.1	18.1	18.1	18.1
91-95	3.8	7.2	10.0	12.2	14.0	15.2	15.8	15.8	15.8	15.8	15.8	15.8	15.8
96-100	3.6	6.6	9.2	11.2	12.6	13.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0
101-105	3.3	6.1	8.4	10.1	11.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
106-110	3.1	5.6	7.6	9.1	10.0	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
111-115	2.8	5.1	6.8	8.0	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
116-120	2.5	4.5	6.0	6.9	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
121-125	2.3	4.0	5.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
126-150	0.9	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4

FLAX

BROWN SOIL ZONE - MOISTURE DEFICIT INDEX 17

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	1.0	1.8	2.6	3.3	3.9	4.4	4.8	5.1	5.4	5.4	5.4	5.4	5.4
6-10	0.9	1.7	2.5	3.1	3.7	4.1	4.4	4.7	4.9	4.9	4.9	4.9	4.9
11-15	0.9	1.7	2.3	2.9	3.4	3.8	4.1	4.3	4.3	4.3	4.3	4.3	4.3
16-20	0.8	1.6	2.2	2.7	3.2	3.5	3.8	3.9	3.9	3.9	3.9	3.9	3.9
21-25	0.8	1.5	2.0	2.5	2.9	3.2	3.4	3.6	3.6	3.6	3.6	3.6	3.6
26-30	0.7	1.4	1.9	2.4	2.7	3.0	3.1	3.2	3.2	3.2	3.2	3.2	3.2
31-35	0.7	1.3	1.8	2.2	2.5	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8
36-40	0.6	1.2	1.6	2.0	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
41-45	0.6	1.1	1.5	1.8	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
46-50	0.5	1.0	1.3	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
51-55	0.5	0.9	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
56-60	0.4	0.8	1.0	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
61-65	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
66-70	0.3	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
71-75	0.3	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
76-80	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
81-85	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
86-90	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
91-95	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
96-100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FLAX

DARK BROWN ZONE - MOISTURE DEFICIT INDEX 13

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	1.2	2.3	3.3	4.2	5.0	5.8	6.4	6.9	7.7	8.1	8.1	8.1	8.1
6-10	1.2	2.2	3.2	4.0	4.8	5.5	6.1	6.5	7.2	7.5	7.5	7.5	7.5
11-15	1.1	2.1	3.0	3.8	4.6	5.2	5.7	6.2	6.7	6.9	6.9	6.9	6.9
16-20	1.1	2.0	2.9	3.6	4.3	4.9	5.4	5.8	6.3	6.3	6.3	6.3	6.3
21-25	1.0	1.9	2.7	3.5	4.1	4.6	5.1	5.4	5.8	5.8	5.8	5.8	5.8
26-30	1.0	1.8	2.6	3.3	3.8	4.3	4.7	5.0	5.3	5.3	5.3	5.3	5.3
31-35	0.9	1.7	2.5	3.1	3.6	4.0	4.4	4.6	4.8	4.8	4.8	4.8	4.8
36-40	0.9	1.6	2.3	2.9	3.4	3.8	4.0	4.2	4.2	4.2	4.2	4.2	4.2
41-45	0.8	1.5	2.2	2.7	3.1	3.5	3.7	3.9	3.9	3.9	3.9	3.9	3.9
46-50	0.8	1.4	2.0	2.5	2.9	3.2	3.4	3.5	3.5	3.5	3.5	3.5	3.5
51-55	0.7	1.3	1.9	2.3	2.7	2.9	3.0	3.1	3.1	3.1	3.1	3.1	3.1
56-60	0.7	1.3	1.7	2.1	2.4	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7
61-65	0.6	1.2	1.6	1.9	2.2	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4
66-70	0.6	1.1	1.4	1.7	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
71-75	0.5	1.0	1.3	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
76-80	0.5	0.9	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
81-85	0.4	0.8	1.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
86-90	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
91-95	0.3	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
96-100	0.3	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
101-105	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
106-110	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
111-115	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
116-120	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
121-125	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FLAX

THIN & THICK, BLACK, GRAY BLACK, & GRAY - MOISTURE DEFICIT INDEX 8

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	160	220
0-5	1.5	2.9	4.2	5.4	6.5	7.5	8.4	9.2	10.6	11.5	12.1	12.1	12.1
6-10	1.4	2.8	4.0	5.2	6.2	7.2	8.1	8.8	10.1	11.0	11.4	11.4	11.4
11-15	1.4	2.7	3.9	5.0	6.0	6.9	7.7	8.4	9.6	10.4	10.8	10.8	10.8
16-20	1.3	2.6	3.7	4.8	5.8	6.6	7.4	8.1	9.1	9.8	10.1	10.1	10.1
21-25	1.3	2.5	3.6	4.6	5.5	6.3	7.1	7.7	8.6	9.2	9.4	9.4	9.4
26-30	1.2	2.4	3.5	4.4	5.3	6.0	6.7	7.3	8.2	8.7	8.7	8.7	8.7
31-35	1.2	2.3	3.3	4.2	5.0	5.8	6.4	6.9	7.7	8.1	8.1	8.1	8.1
36-40	1.2	2.2	3.2	4.0	4.8	5.5	6.1	6.5	7.2	7.5	7.5	7.5	7.5
41-45	1.1	2.1	3.0	3.8	4.6	5.2	5.7	6.2	6.7	6.9	6.9	6.9	6.9
46-50	1.1	2.0	2.9	3.7	4.3	4.9	5.4	5.8	6.3	6.3	6.3	6.3	6.3
51-55	1.0	1.9	2.7	3.5	4.1	4.6	5.1	5.4	5.8	5.8	5.8	5.8	5.8
56-60	1.0	1.8	2.6	3.3	3.8	4.3	4.7	5.0	5.3	5.3	5.3	5.3	5.3
61-65	0.9	1.7	2.5	3.1	3.6	4.0	4.4	4.6	4.8	4.8	4.8	4.8	4.8
66-70	0.9	1.6	2.3	2.9	3.4	3.8	4.1	4.2	4.2	4.2	4.2	4.2	4.2
71-75	0.8	1.5	2.2	2.7	3.1	3.5	3.7	3.9	3.9	3.9	3.9	3.9	3.9
76-80	0.8	1.4	2.0	2.5	2.9	3.2	3.4	3.5	3.5	3.5	3.5	3.5	3.5
81-85	0.7	1.3	1.9	2.3	2.7	2.9	3.0	3.1	3.1	3.1	3.1	3.1	3.1
86-90	0.7	1.3	1.7	2.1	2.4	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7
91-95	0.6	1.2	1.6	1.9	2.2	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4
96-100	0.6	1.1	1.4	1.7	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
101-105	0.5	1.0	1.3	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
106-110	0.5	0.9	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
111-115	0.4	0.8	1.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
116-120	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
121-125	0.3	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
126-150	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

FLAX

IRRIGATION (All zones) MOISTURE DEFICIT INDEX 1

NO_3-N In 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	1.9	3.7	5.4	7.0	8.5	9.9	11.2	12.4	14.6	16.3	17.7	19.4	19.4
6-10	1.8	3.6	5.2	6.8	8.2	9.6	10.9	12.0	14.1	15.8	17.1	18.5	18.5
11-15	1.8	3.5	5.1	6.6	8.0	9.3	10.5	11.7	13.6	15.2	16.4	17.6	17.6
16-20	1.7	3.4	4.9	6.4	7.8	9.0	10.2	11.3	13.1	14.6	15.7	16.8	16.8
21-25	1.7	3.3	4.8	6.2	7.5	8.7	9.9	10.9	12.7	14.0	15.1	15.9	15.9
26-30	1.6	3.2	4.7	6.0	7.3	8.5	9.5	10.5	12.2	13.5	14.4	14.4	14.4
31-35	1.6	3.1	4.5	5.8	7.0	8.2	9.2	10.1	11.7	12.9	13.7	13.7	13.7
36-40	1.6	3.0	4.4	5.6	6.8	7.9	8.9	9.7	11.2	12.3	13.0	13.0	13.0
41-45	1.5	2.9	4.2	5.4	6.6	7.6	8.5	9.4	10.8	11.8	12.4	12.4	12.4
46-50	1.5	2.8	4.1	5.3	6.3	7.3	8.2	9.0	10.3	11.2	11.7	11.7	11.7
51-55	1.4	2.7	3.9	5.1	6.1	7.0	7.9	8.6	9.8	10.6	11.0	11.0	11.0
56-60	1.4	2.6	3.8	4.9	5.9	6.7	7.5	8.2	9.3	10.0	10.4	10.4	10.4
61-65	1.3	2.5	3.7	4.7	5.6	6.5	7.2	7.8	8.8	9.5	9.7	9.7	9.7
66-70	1.3	2.4	3.5	4.5	5.4	6.2	6.9	7.5	8.4	8.9	8.9	8.9	8.9
71-75	1.2	2.3	3.4	4.3	5.1	5.9	6.5	7.1	7.9	8.3	8.3	8.3	8.3
76-80	1.2	2.2	3.2	4.1	4.9	5.6	6.2	6.7	7.4	7.7	7.7	7.7	7.7
81-85	1.1	2.2	3.1	3.9	4.7	5.3	5.9	6.3	6.9	7.2	7.2	7.2	7.2
86-90	1.1	2.1	2.9	3.7	4.4	5.0	5.5	5.9	6.5	6.5	6.5	6.5	6.5
91-95	1.0	2.0	2.8	3.5	4.2	4.7	5.2	5.5	6.0	6.0	6.0	6.0	6.0
96-100	1.0	1.9	2.7	3.3	3.9	4.4	4.9	5.2	5.5	5.5	5.5	5.5	5.5
101-105	0.9	1.8	2.5	3.2	3.7	4.2	4.5	4.8	5.0	5.0	5.0	5.0	5.0
106-110	0.9	1.7	2.4	3.0	3.5	3.9	4.2	4.4	4.4	4.4	4.4	4.4	4.4
111-115	0.8	1.6	2.2	2.8	3.2	3.6	3.9	4.0	4.0	4.0	4.0	4.0	4.0
116-120	0.8	1.5	2.1	2.6	3.0	3.3	3.5	3.6	3.6	3.6	3.6	3.6	3.6
121-125	0.7	1.4	1.9	2.4	2.8	3.0	3.2	3.3	3.3	3.3	3.3	3.3	3.3
126-150	0.5	0.9	1.2	1.4	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6

RAPE

BROWN SOIL ZONE - MOISTURE DEFICIT INDEX 17

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	1.2	2.3	3.2	4.1	4.8	5.4	5.8	6.2	6.5	6.5	6.5	6.5	6.5
6-10	1.1	2.2	3.1	3.8	4.5	5.0	5.4	5.7	5.7	5.6	5.7	5.7	5.7
11-15	1.1	2.0	2.9	3.6	4.2	4.6	5.0	5.2	5.2	5.2	5.2	5.2	5.2
16-20	1.0	1.9	2.7	3.3	3.9	4.3	4.6	4.7	4.7	4.7	4.7	4.7	4.7
21-25	1.0	1.8	2.5	3.1	3.6	3.9	4.1	4.2	4.2	4.2	4.2	4.2	4.2
26-30	0.9	1.7	2.3	2.9	3.3	3.5	3.7	3.7	3.7	3.7	3.7	3.7	3.7
31-35	0.8	1.5	2.1	2.6	3.0	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3
36-40	0.8	1.4	2.0	2.4	2.6	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
41-45	0.7	1.3	1.8	2.1	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
46-50	0.7	1.2	1.6	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
51-55	0.6	1.1	1.4	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
56-60	0.5	0.9	1.2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
61-65	0.5	0.8	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
66-70	0.4	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
71-75	0.3	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
76-80	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
81-85	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
86-90	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
91-95	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
96-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RAPE

DARK BROWN ZONE - MOISTURE DEFICIT INDEX 13

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	1.5	2.9	4.1	5.3	6.3	7.2	7.9	8.6	9.5	9.9	9.9	9.9	9.9
6-10	1.4	2.8	3.9	5.0	6.0	6.8	7.5	8.1	8.8	9.1	9.1	9.1	9.1
11-15	1.4	2.6	3.8	4.8	5.7	6.4	7.1	7.6	8.2	8.2	8.2	8.2	8.2
16-20	1.3	2.5	3.6	4.5	5.3	6.0	6.6	7.1	7.6	7.6	7.6	7.6	7.6
21-25	1.3	2.4	3.4	4.3	5.0	5.7	6.2	6.6	7.0	7.0	7.0	7.0	7.0
26-30	1.2	2.3	3.2	4.0	4.7	5.3	5.8	6.1	6.4	6.4	6.4	6.4	6.4
31-35	1.1	2.1	3.0	3.8	4.4	4.9	5.3	5.6	5.6	5.6	5.6	5.6	5.6
36-40	1.1	2.0	2.8	3.5	4.1	4.6	4.9	5.1	5.1	5.1	5.1	5.1	5.1
41-45	1.0	1.9	2.7	3.3	3.8	4.2	4.5	4.6	4.6	4.6	4.6	4.6	4.6
46-50	0.9	1.8	2.5	3.0	3.5	3.8	4.0	4.1	4.1	4.1	4.1	4.1	4.1
51-55	0.9	1.6	2.3	2.8	3.2	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6
56-60	0.8	1.5	2.1	2.6	2.9	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2
61-65	0.8	1.4	1.9	2.3	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
66-70	0.7	1.3	1.7	2.1	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
71-75	0.6	1.2	1.6	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
76-80	0.6	1.0	1.4	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
81-85	0.5	0.9	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
86-90	0.5	0.8	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
91-95	0.4	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
96-100	0.3	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
101-105	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
106-110	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
111-115	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
116-120	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RAPE

THIN & THICK, BLACK, GRAY BLACK, & GRAY - MOISTURE DEFICIT INDEX 8

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	1.9	3.6	5.2	6.7	8.1	9.4	10.5	11.5	13.1	14.3	15.0	15.0	15.0
6-10	1.8	3.5	5.0	6.5	7.8	9.0	10.1	11.0	12.5	13.6	14.1	14.1	14.1
11-15	1.7	3.4	4.9	6.2	7.5	8.6	9.6	10.5	11.9	12.8	13.3	13.3	13.3
16-20	1.7	3.2	4.7	6.0	7.2	8.3	9.2	10.0	11.3	12.1	12.4	12.4	12.4
21-25	1.6	3.1	4.5	5.7	6.9	7.9	8.8	9.5	10.7	11.4	11.4	11.4	11.4
26-30	1.6	3.0	4.2	5.5	6.6	7.5	8.3	9.0	10.1	10.6	10.6	10.6	10.6
31-35	1.5	2.9	4.1	5.3	6.3	7.2	7.9	8.6	9.5	9.9	9.9	9.9	9.9
36-40	1.4	2.8	3.9	5.0	6.0	6.8	7.5	8.1	8.9	9.1	9.1	9.1	9.1
41-45	1.4	2.6	3.8	4.8	5.7	6.4	7.1	7.6	8.2	8.2	8.2	8.2	8.2
46-50	1.3	2.5	3.6	4.5	5.3	6.0	6.6	7.1	7.6	7.6	7.6	7.6	7.6
51-55	1.3	2.4	3.4	4.3	5.0	5.7	6.2	6.6	7.0	7.0	7.0	7.0	7.0
56-60	1.2	2.3	3.2	4.0	4.7	5.3	5.8	6.1	6.4	6.4	6.4	6.4	6.4
61-65	1.1	2.1	3.0	3.8	4.4	4.9	5.3	5.6	5.6	5.6	5.6	5.6	5.6
66-70	1.1	2.0	2.8	3.5	4.1	4.6	4.9	5.1	5.1	5.1	5.1	5.1	5.1
71-75	1.0	1.9	2.7	3.3	3.8	4.2	4.5	4.6	4.6	4.6	4.6	4.6	4.6
76-80	0.9	1.8	2.5	3.0	3.5	3.8	4.0	4.1	4.1	4.1	4.1	4.1	4.1
81-85	0.9	1.6	2.3	2.8	3.2	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6
86-90	0.8	1.5	2.1	2.6	2.9	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2
91-95	0.8	1.4	1.9	2.3	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
96-100	0.7	1.3	1.7	2.1	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
101-105	0.6	1.2	1.6	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
106-110	0.6	1.0	1.4	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
111-115	0.5	0.9	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
116-120	0.5	0.8	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
121-125	0.4	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
126-150	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

RAPE

IRRIGATION (All zones) MOISTURE DEFICIT INDEX 1

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	2.4	4.6	6.8	8.8	10.7	12.5	14.1	15.6	18.3	20.5	22.2	24.1	24.1
6-10	2.3	4.5	6.6	8.5	10.4	12.1	13.7	15.1	17.7	19.8	21.3	23.0	23.0
11-15	2.3	4.4	6.4	8.3	10.1	11.7	13.2	14.6	17.1	19.0	20.5	21.9	21.9
16-20	2.2	4.3	6.2	8.1	9.8	11.4	12.8	14.2	16.5	18.3	19.6	20.8	20.8
21-25	2.1	4.2	6.0	7.8	9.5	11.0	12.4	13.7	15.9	17.5	18.8	18.8	18.8
26-30	2.1	4.0	5.9	7.6	9.2	10.6	12.0	13.2	15.2	16.8	17.9	17.9	17.9
31-35	2.0	3.9	5.7	7.3	8.8	10.2	11.5	12.7	14.6	16.1	17.0	17.0	17.0
36-40	2.0	3.8	5.5	7.1	8.5	9.9	11.1	12.2	14.0	15.3	16.2	16.2	16.2
41-45	1.9	3.7	5.3	6.8	8.2	9.5	10.7	11.7	13.4	14.6	15.3	15.3	15.3
46-50	1.8	3.5	5.1	6.6	7.9	9.1	10.2	11.2	12.8	13.9	14.5	14.5	14.5
51-55	1.8	3.4	4.9	6.3	7.6	8.8	9.8	10.7	12.2	13.1	13.6	13.6	13.6
56-60	1.7	3.3	4.8	6.1	7.3	8.4	9.4	10.2	11.6	12.4	12.7	12.7	12.7
61-65	1.6	3.2	4.6	5.8	7.0	8.0	8.9	9.7	10.9	11.7	11.7	11.7	11.7
66-70	1.6	3.0	4.4	5.6	6.7	7.7	8.5	9.2	10.3	10.9	10.9	10.9	10.9
71-75	1.5	2.9	4.2	5.4	6.4	7.3	8.1	8.8	9.7	10.2	10.2	10.2	10.2
76-80	1.5	2.8	4.0	5.1	6.1	6.9	7.7	8.3	9.1	9.4	9.4	9.4	9.4
81-85	1.4	2.7	3.8	4.9	5.8	6.6	7.2	7.8	8.5	8.5	8.5	8.5	8.5
86-90	1.3	2.6	3.7	4.6	5.5	6.2	6.8	7.3	7.9	7.9	7.9	7.9	7.9
91-95	1.3	2.4	3.5	4.4	5.2	5.8	6.4	6.8	7.3	7.3	7.3	7.3	7.3
96-100	1.2	2.3	3.3	4.1	4.9	5.5	5.9	6.3	6.6	6.6	6.6	6.6	6.6
101-105	1.2	2.2	3.1	3.9	4.6	5.1	5.5	5.8	5.8	5.8	5.8	5.8	5.8
106-110	1.1	2.1	2.9	3.6	4.2	4.7	5.1	5.3	5.3	5.3	5.3	5.3	5.3
111-115	1.0	1.9	2.7	3.4	3.9	4.4	4.7	4.8	4.8	4.8	4.8	4.8	4.8
116-120	1.0	1.8	2.5	3.1	3.6	4.0	4.2	4.3	4.3	4.3	4.3	4.3	4.3
121-125	0.9	1.7	2.4	2.9	3.3	3.6	3.8	3.8	3.8	3.8	3.8	3.8	3.8
126-150	0.6	1.1	1.4	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8

OATS

BROWN SOIL ZONE - MOISTURE DEFICIT INDEX 17

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	160	220
0-5	5.0	9.4	13.2	16.5	19.2	21.3	22.9	23.9	23.9	23.9	23.9	23.9	23.9
6-10	4.7	8.8	12.4	15.4	17.8	19.6	20.9	21.6	21.6	21.6	21.6	21.6	21.6
11-15	4.4	8.3	11.5	14.2	16.3	17.9	18.9	19.3	19.3	19.3	19.3	19.3	19.3
16-20	4.1	7.7	10.7	13.1	14.9	16.2	16.9	16.9	16.9	16.9	16.9	16.9	16.9
21-25	3.8	7.1	9.8	11.9	13.5	14.5	14.9	14.9	14.9	14.9	14.9	14.9	14.9
26-30	3.6	6.5	8.9	10.8	12.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
31-35	3.3	6.0	8.1	9.6	10.6	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
36-40	3.0	5.4	7.2	8.5	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
41-45	2.7	4.8	6.4	7.3	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
46-50	2.4	4.2	5.5	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
51-55	2.1	3.7	4.7	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
56-60	1.8	3.1	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
61-65	1.6	2.5	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
66-70	1.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
71-75	1.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
76-80	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
81-85	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
86-90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91-95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OATS

DARK BROWN SOIL ZONE - MOISTURE DEFICIT INDEX 13

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	6.1	11.7	16.7	21.1	24.9	28.2	30.9	33.0	35.5	35.5	35.5	35.5	35.5
6-10	5.8	11.1	15.8	19.9	23.5	26.5	28.9	30.7	32.7	32.7	32.7	32.7	32.7
11-15	5.6	10.5	14.9	18.8	22.1	24.7	26.9	28.4	29.8	29.8	29.8	29.8	29.8
16-20	5.3	10.0	14.1	17.6	20.6	23.0	24.9	26.1	26.1	26.1	26.1	26.1	26.1
21-25	5.0	9.4	13.2	16.5	19.2	21.3	22.9	23.8	23.8	23.8	23.8	23.8	23.8
26-30	4.7	8.8	12.4	15.4	17.8	19.6	20.9	21.5	21.5	21.5	21.5	21.5	21.5
31-35	4.4	8.2	11.5	14.2	16.3	17.9	18.9	19.3	19.3	19.3	19.3	19.3	19.3
36-40	4.1	7.7	10.7	13.1	14.9	16.2	16.9	16.9	16.9	16.9	16.9	16.9	16.9
41-45	3.8	7.1	9.8	11.9	13.5	14.4	14.8	14.8	14.8	14.8	14.8	14.8	14.8
46-50	3.6	6.5	8.9	10.8	12.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
51-55	3.3	6.0	8.1	9.6	10.8	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
56-60	3.0	5.4	7.2	8.5	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
61-65	2.7	4.8	6.4	7.3	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
66-70	2.4	4.2	5.5	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
71-75	2.1	3.7	4.6	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
76-80	1.8	3.1	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
81-85	1.5	2.5	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
86-90	1.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
91-95	1.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
96-100	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
101-105	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
106-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-115	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OATS

THIN & THICK, BLACK, GRAY BLACK, & GRAY - MOISTURE DEFICIT INDEX 8

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	180	220
0-5	7.6	14.5	20.9	26.8	32.1	36.7	40.9	44.4	49.8	52.9	52.9	52.9	52.9
6-10	7.3	14.0	20.1	25.6	30.6	35.0	38.9	42.1	46.9	49.5	49.5	49.5	49.5
11-15	7.0	13.4	19.2	24.5	29.2	33.3	36.9	39.8	44.1	46.0	46.0	46.0	46.0
16-20	6.7	12.8	18.4	23.4	27.8	31.6	34.9	37.5	41.2	42.6	42.6	42.6	42.6
21-25	6.4	12.2	17.5	22.2	26.3	29.9	32.9	35.3	38.4	38.4	38.4	38.4	38.4
26-30	6.1	11.7	16.7	21.1	24.9	28.2	30.9	33.0	35.5	35.5	35.5	35.5	35.5
31-35	5.8	11.1	15.8	19.9	23.5	26.4	28.9	30.7	32.6	32.6	32.6	32.6	32.6
36-40	5.6	10.5	14.9	18.8	22.0	24.7	26.8	28.4	29.8	29.8	29.8	29.8	29.8
41-45	5.3	10.0	14.1	17.6	20.6	23.0	24.8	26.1	26.1	26.1	26.1	26.1	26.1
46-50	5.0	9.4	13.2	16.5	19.2	21.3	22.8	23.8	23.8	23.8	23.8	23.8	23.8
51-55	4.7	8.8	12.4	15.3	17.7	19.6	20.8	21.5	21.5	21.5	21.5	21.5	21.5
56-60	4.4	8.2	11.5	14.2	16.3	17.9	18.8	19.2	19.2	19.2	19.2	19.2	19.2
61-65	4.1	7.7	10.6	13.1	14.9	16.1	16.8	16.8	16.8	16.8	16.8	16.8	16.8
66-70	3.8	7.1	9.8	11.9	13.5	14.4	14.8	14.8	14.8	14.8	14.8	14.8	14.8
71-75	3.5	6.5	8.9	10.8	12.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
76-80	3.3	6.0	8.1	9.6	10.6	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
81-85	3.0	5.4	7.2	8.5	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
86-90	2.7	4.8	6.4	7.3	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
91-95	2.4	4.2	5.5	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
96-100	2.1	3.7	4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
101-105	1.8	3.1	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
106-110	1.5	2.5	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
111-115	1.3	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
116-120	1.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
121-125	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
126-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OATS

IRRIGATION (All zones) MOISTURE DEFICIT INDEX 1

NO_3-N in 0-24" depth lb/Ac	Fertilizer N Applied (lb/Ac)												
	10	20	30	40	50	60	70	80	100	120	140	160	220
0-5	9.6	18.5	26.9	34.8	42.0	48.7	54.9	60.4	69.8	76.9	81.7	81.7	81.7
6-10	9.3	18.0	26.1	33.8	40.6	47.0	52.9	58.1	66.9	73.4	77.7	77.7	77.7
11-15	9.0	17.4	25.2	32.5	39.2	45.3	50.9	55.8	64.1	70.0	73.7	73.7	73.7
16-20	8.7	16.8	24.4	31.3	37.8	43.6	48.9	53.5	61.2	66.6	69.7	69.7	69.7
21-25	8.4	16.2	23.5	30.2	30.3	41.9	46.9	51.3	58.3	63.1	65.7	65.7	65.7
26-30	8.1	15.7	22.7	29.1	34.9	40.2	44.8	49.0	55.5	59.7	61.7	61.7	61.7
31-35	7.8	15.1	21.8	27.9	33.5	38.4	42.8	46.7	52.6	56.3	57.7	57.7	57.7
36-40	7.6	14.5	20.9	26.8	32.0	36.7	40.8	44.4	49.8	52.8	52.8	52.8	52.8
41-45	7.3	14.0	20.1	25.6	30.6	35.0	38.8	42.1	46.9	49.4	49.4	49.4	49.4
46-50	7.0	13.4	19.2	24.5	29.2	33.3	36.8	39.8	44.0	46.0	46.0	46.0	46.0
51-55	6.7	12.8	18.4	23.3	27.7	31.6	34.8	37.5	41.2	42.5	42.5	42.5	42.5
56-60	6.4	12.2	17.5	22.2	26.3	29.9	32.8	35.2	38.3	38.3	38.3	38.3	38.3
61-65	6.1	11.7	16.6	21.0	24.9	28.1	30.8	32.9	35.5	35.5	35.5	35.5	35.5
66-70	5.8	11.1	15.8	19.9	23.5	26.4	28.8	30.7	32.6	32.6	32.6	32.6	32.6
71-75	5.5	10.5	14.9	18.8	22.0	24.7	26.8	28.4	29.7	29.7	29.7	29.7	29.7
76-80	5.3	10.0	14.1	17.6	20.6	23.0	24.8	26.1	26.1	26.1	26.1	26.1	26.1
81-85	5.0	9.4	13.2	16.5	19.2	21.3	22.8	23.8	23.8	23.8	23.8	23.8	23.8
86-90	4.7	8.8	12.4	15.3	17.7	19.6	20.8	21.5	21.5	21.5	21.5	21.5	21.5
91-95	4.4	8.2	11.5	14.2	16.3	17.8	18.8	19.2	19.2	19.2	19.2	19.2	19.2
96-100	4.1	7.7	10.6	13.0	14.9	16.1	16.8	16.8	16.8	16.8	16.8	16.8	16.8
101-105	3.8	7.1	9.8	11.9	13.4	14.4	14.8	14.8	14.8	14.8	14.8	14.8	14.8
106-110	3.5	6.5	8.9	10.7	12.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
111-115	3.3	5.9	8.1	9.6	10.6	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
116-120	3.0	5.4	7.2	8.5	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
121-125	2.7	4.8	6.3	7.3	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
126-150	1.3	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

APPENDIX B

Expected Yield Increase Tables for Phosphate

EXPECTED YIELD INCREASES - PHOSPHATE

$NaHCO_3$-P (lb/Ac, 0-6'')		P_2O_5 (lb/Ac) 10	20	30	40	50
		Yield Increase (bus/Ac)				
	WHEAT					
0 - 10		3.4	6.0	7.5	8.3	8.6
11 - 15		3.0	5.1	6.3	6.8	7.0
16 - 20		2.6	4.4	5.3	5.6	5.8
21 - 30		2.2	3.5	4.0	4.4	4.6
31 - 40		1.7	2.4	2.9	3.1	3.3
41 - 60		1.0	1.4	1.8	2.1	2.2
61 +		0.4	0.8	1.2	1.4	1.5
	BARLEY					
0 - 10		5.5	9.8	12.4	13.6	13.8
11 - 15		4.9	8.6	10.6	11.2	11.7
16 - 20		4.3	7.3	8.9	9.5	9.7
21 - 30		3.7	5.9	6.8	7.3	7.6
31 - 40		2.5	4.2	4.9	5.3	5.4
41 - 60		1.5	2.2	2.6	2.8	2.8
61 +		0.7	1.5	1.9	2.0	2.0
	FLAX					
0 - 10		2.9	4.4	4.7	4.8	5.0
11 - 15		2.5	3.4	3.6	3.7	3.7
16 - 20		1.9	2.5	2.7	2.7	2.7
21 - 30		1.2	1.4	1.5	1.5	1.5
31 - 40		0.8	1.0	4.0	1.0	1.0
41 +		0.6	0.7	0.7	0.7	0.7
	RAPE					
0 - 10		3.75	5.5	5.9	6.2	6.4
11 - 15		3.3	4.5	4.9	5.0	5.0
16 - 20		3.25	3.7	3.8	3.8	3.8
21 - 30		2.0	2.4	2.4	2.4	2.4
31 - 40		1.5	1.8	1.8	1.8	1.8
41 - 60		1.1	1.35	1.4	1.4	1.4
61 +		0.25	0.3	0.4	0.4	0.4
	OATS					
0 - 10		7.6	13.8	17.4	19.0	19.3
11 - 15		6.8	12.1	15.0	16.0	16.3
16 - 20		6.0	10.2	12.5	13.2	13.5
21 - 30		5.1	8.3	9.5	10.3	10.6
31 - 40		3.6	5.9	6.9	7.4	7.6
41 +		2.1	3.5	4.2	4.4	4.5